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Belghoul

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(54) **MOBILE COMMUNICATION DEVICE WITH MULTIPLE WIRELESS TRANSCEIVERS AND METHODS FOR USE THEREWITH**

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H04W 36/00 (2009.01)
H04W 88/06 (2009.01)
H04W 48/16 (2009.01)

(52) **U.S. Cl.**
CPC ***H04W 88/06*** (2013.01); ***H04W 36/0022*** (2013.01); *H04W 48/16* (2013.01)

(58) **Field of Classification Search**
CPC H04L 12/46; H04L 69/24; H04W 84/045; H04W 40/04; H04W 36/0055
USPC 455/444, 443, 439
See application file for complete search history.

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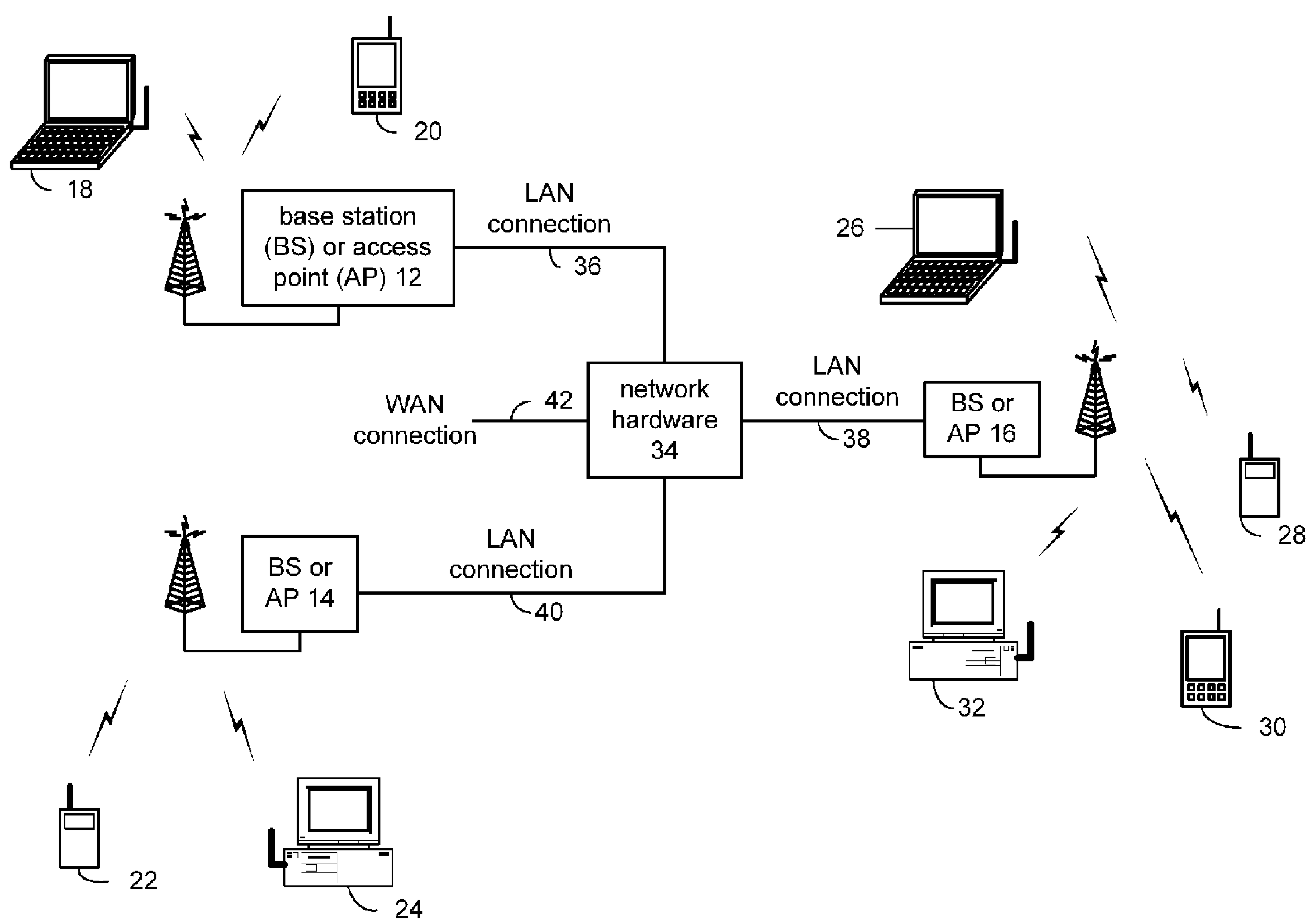
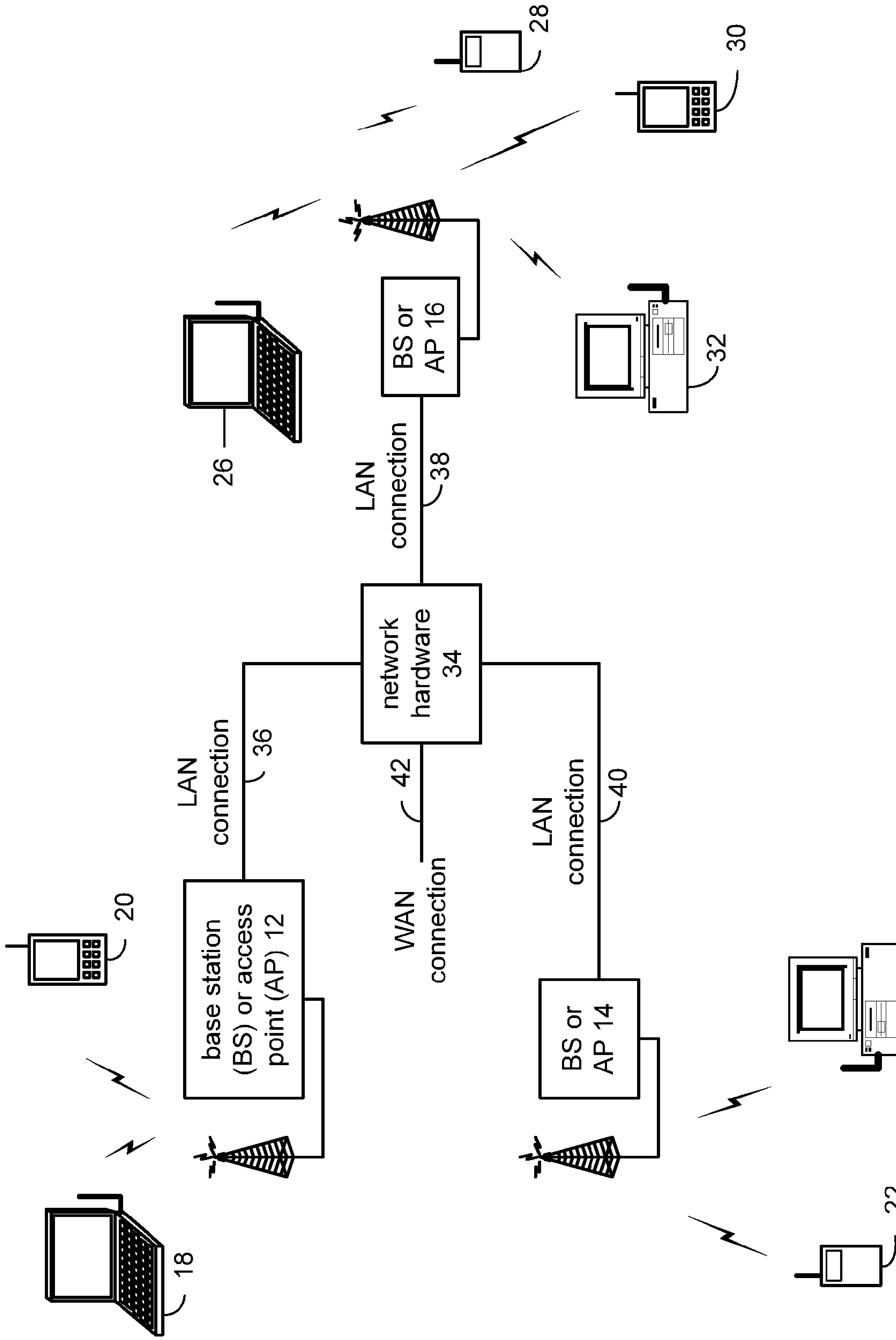
(57) **ABSTRACT**

A first wireless transceiver communicates pre-association data via a first wireless network, the pre-association data relating to a second wireless network, wherein the first wireless network supports communication via a first wireless protocol and wherein the second wireless network supports communication via a second wireless protocol that is different from the first wireless protocol. A second wireless transceiver communicates the pre-association data with the first wireless transceiver via a transceiver interface and processes the pre-association data to support an association by the second wireless transceiver with the second wireless network.

20 Claims, 10 Drawing Sheets





base station (BS) or access point (AP) 12
BS or AP 14
BS or AP 16
network hardware 34
LAN connection
36
LAN connection
38
LAN connection
40
WAN connection
42
18
20
22
24
26
28
30
32

FIG. 1

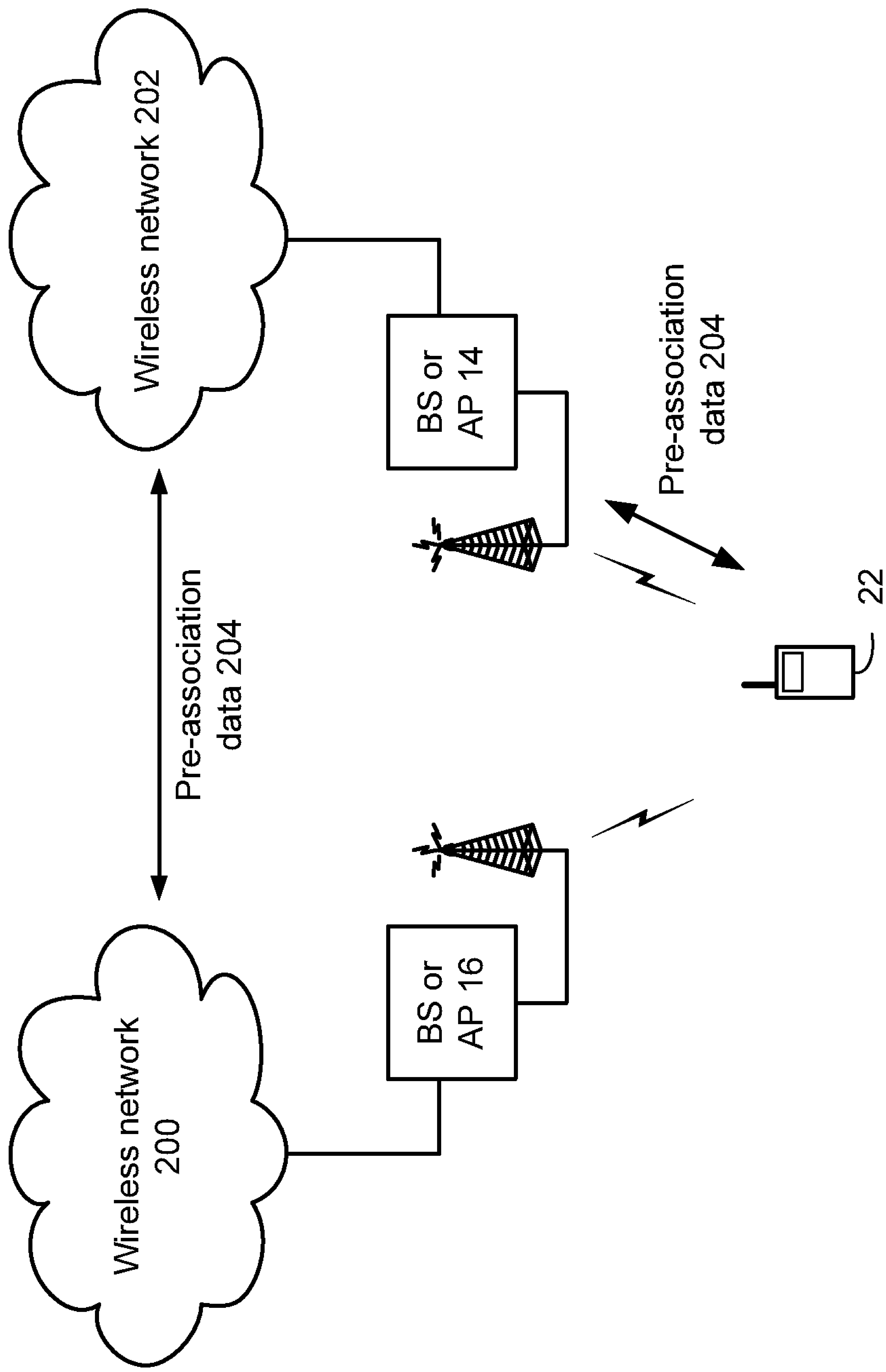

Wireless network 202
BS or AP 14
Pre-association data 204
Pre-association data 204
22
Wireless network 200
BS or AP 16

FIG. 2

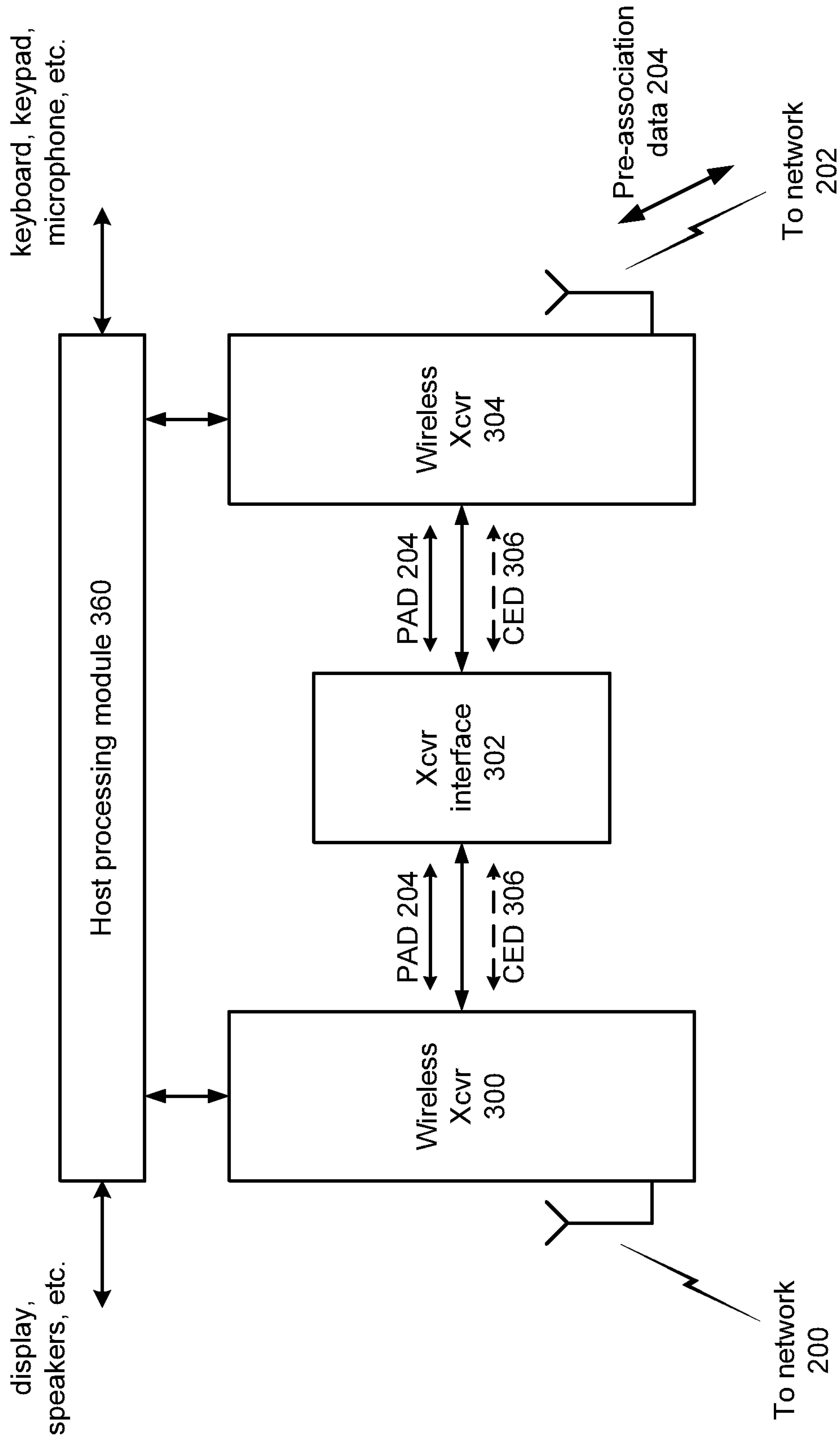

keyboard, keypad, microphone, etc.
Pre-association data 204
To network 202
Wireless Xcvr 304
PAD 204
CED 306
Host processing module 360
Xcvr interface 302
PAD 204
CED 306
Wireless Xcvr 300
display, speakers, etc.
To network 200

FIG. 3

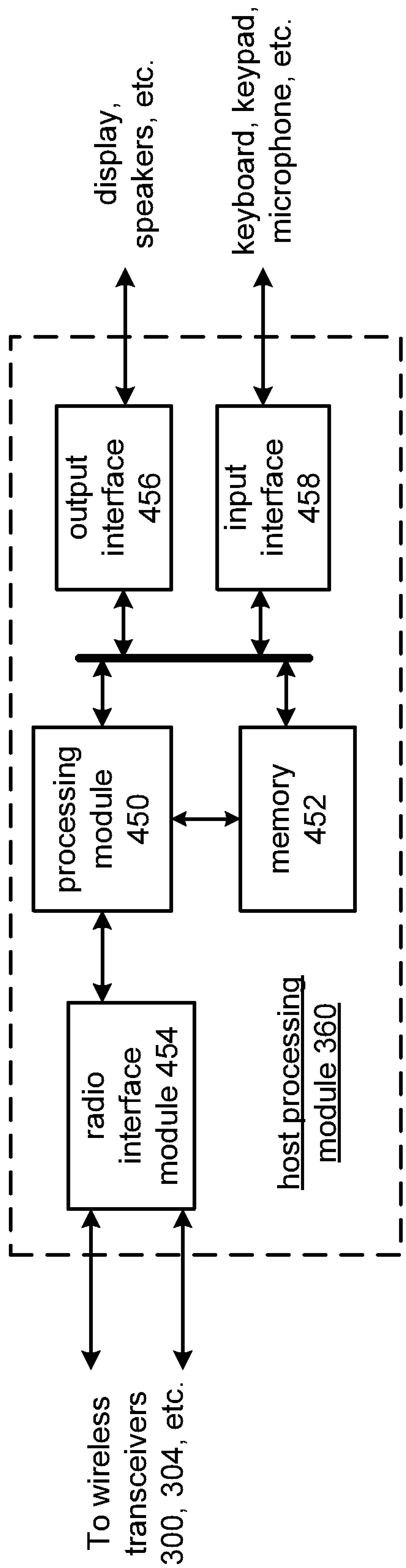

display,
speakers, etc.
keyboard, keypad,
microphone, etc.
output
interface
456
input
interface
458
processing
module
450
memory
452
radio
interface
module 454
host processing
module 360
To wireless
transceivers
300, 304, etc.

FIG. 4

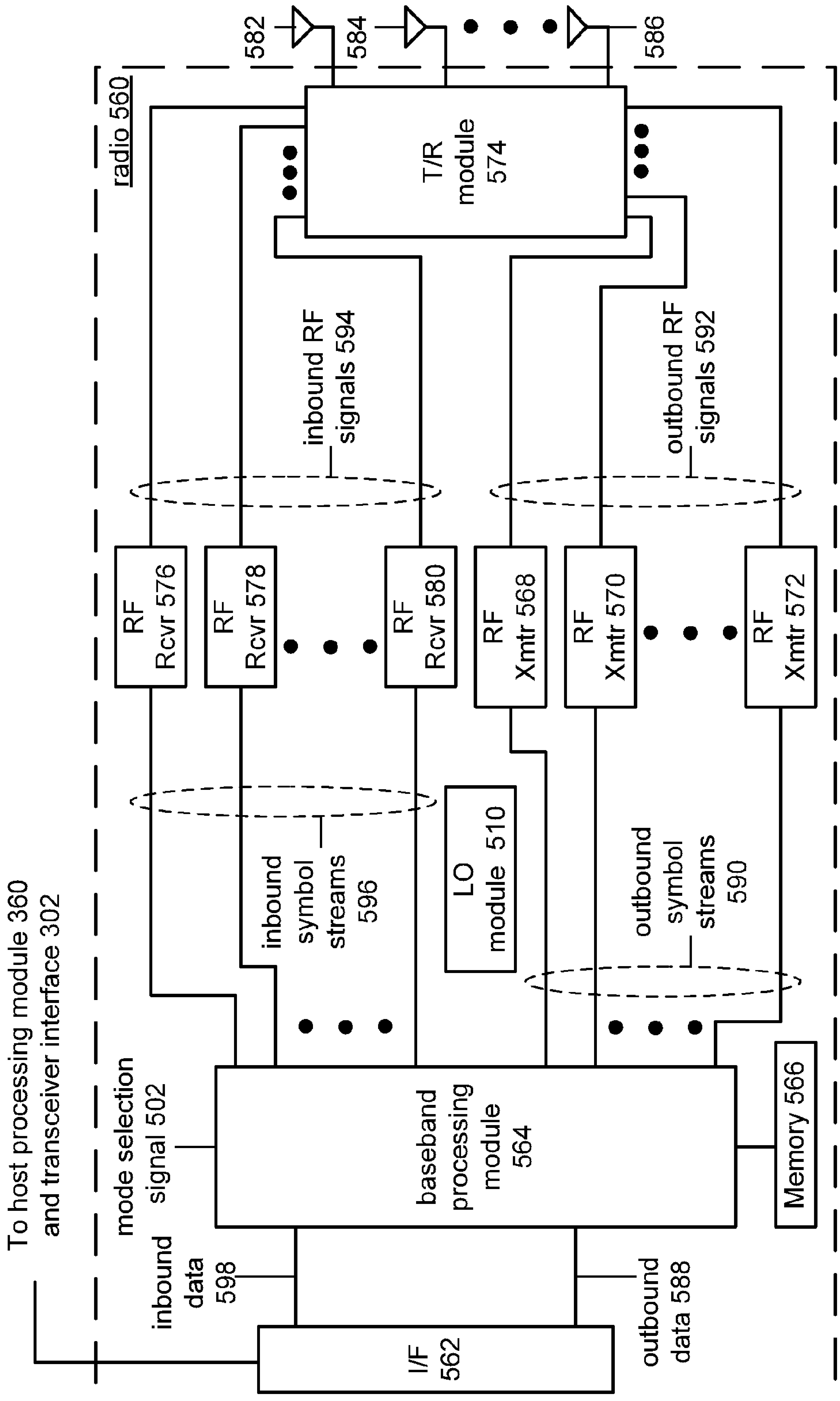

582
584
586
radio 560
T/R
module
574
inbound RF
signals 594
outbound RF
signals 592
RF
Rcvr 576
RF
Rcvr 578
RF
Rcvr 580
RF
Xmtr 568
RF
Xmtr 570
RF
Xmtr 572
inbound
symbol
streams
596
LO
module 510
outbound
symbol
streams
590
To host processing module 360
and transceiver interface 302
mode selection
signal 502
baseband
processing
module
564
Memory 566
inbound
data
598
outbound
data 588
I/F
562

FIG. 5

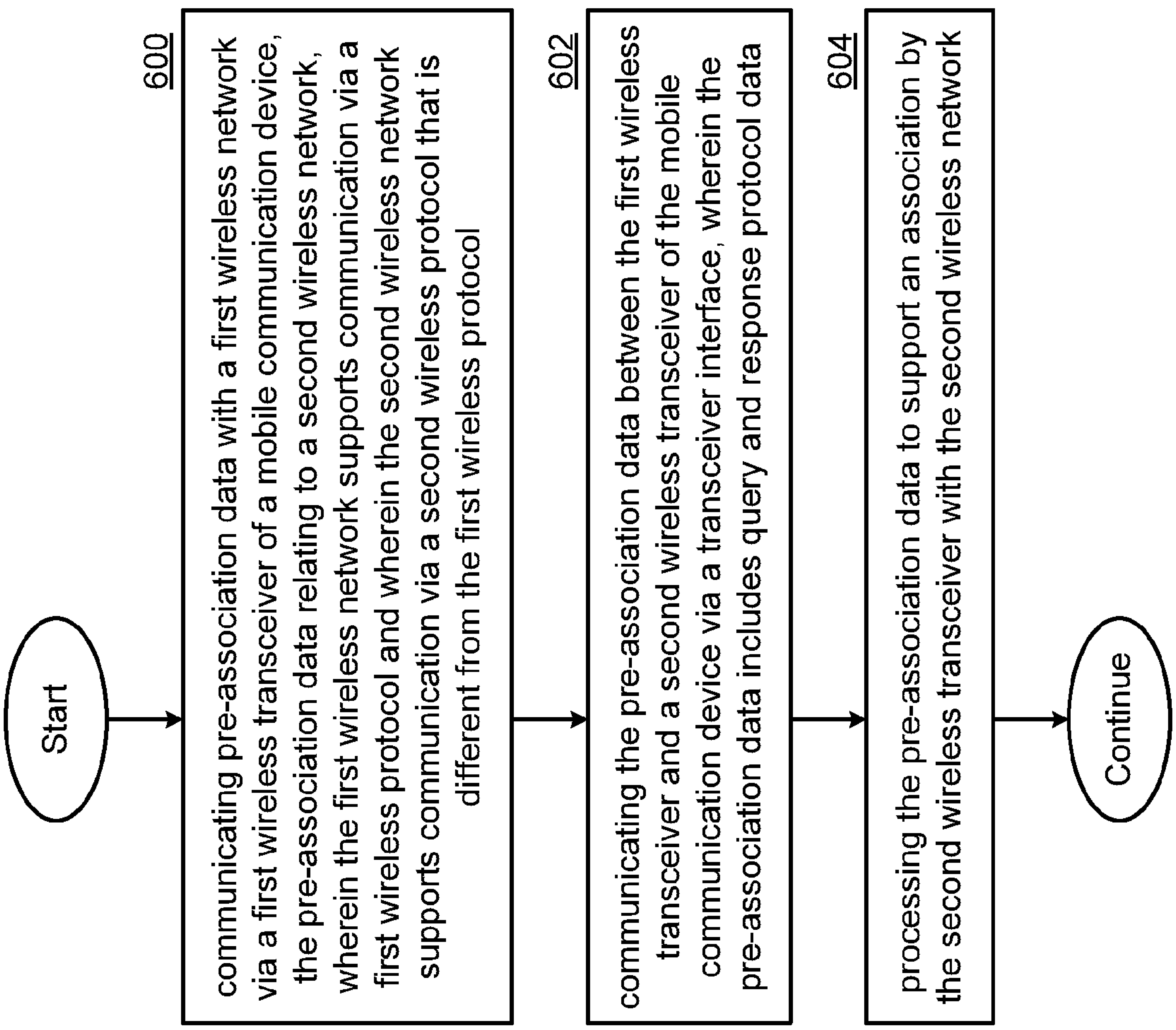

Start
600
communicating pre-association data with a first wireless network via a first wireless transceiver of a mobile communication device, the pre-association data relating to a second wireless network, wherein the first wireless network supports communication via a first wireless protocol and wherein the second wireless network supports communication via a second wireless protocol that is different from the first wireless protocol
602
communicating the pre-association data between the first wireless transceiver and a second wireless transceiver of the mobile communication device via a transceiver interface, wherein the pre-association data includes query and response protocol data
604
processing the pre-association data to support an association by the second wireless transceiver with the second wireless network
Continue

FIG. 6

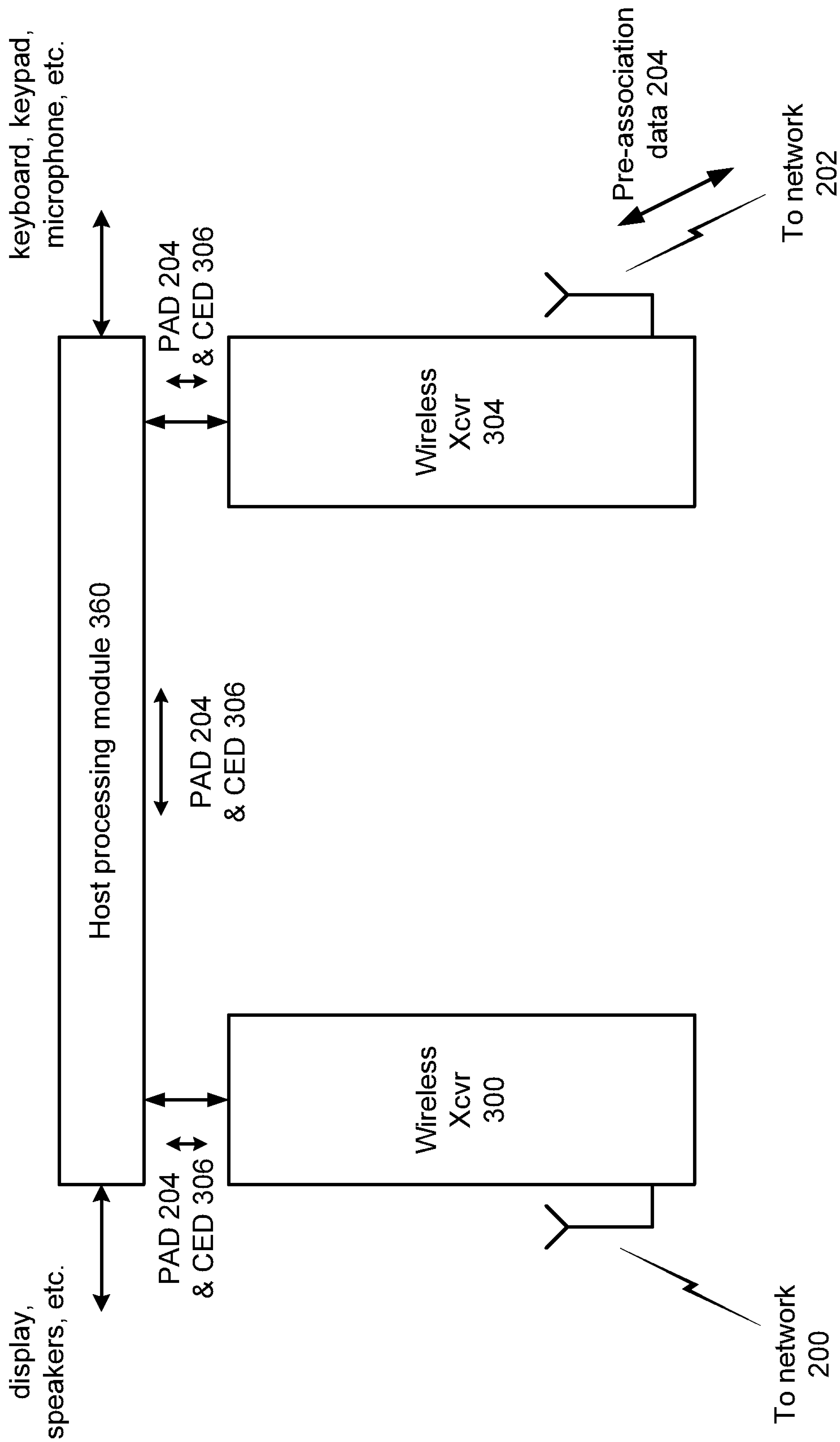

keyboard, keypad, microphone, etc.
Pre-association data 204
To network 202
PAD 204 & CED 306
Wireless Xcvr 304
Host processing module 360
PAD 204 & CED 306
Wireless Xcvr 300
PAD 204 & CED 306
display, speakers, etc.
To network 200

FIG. 7

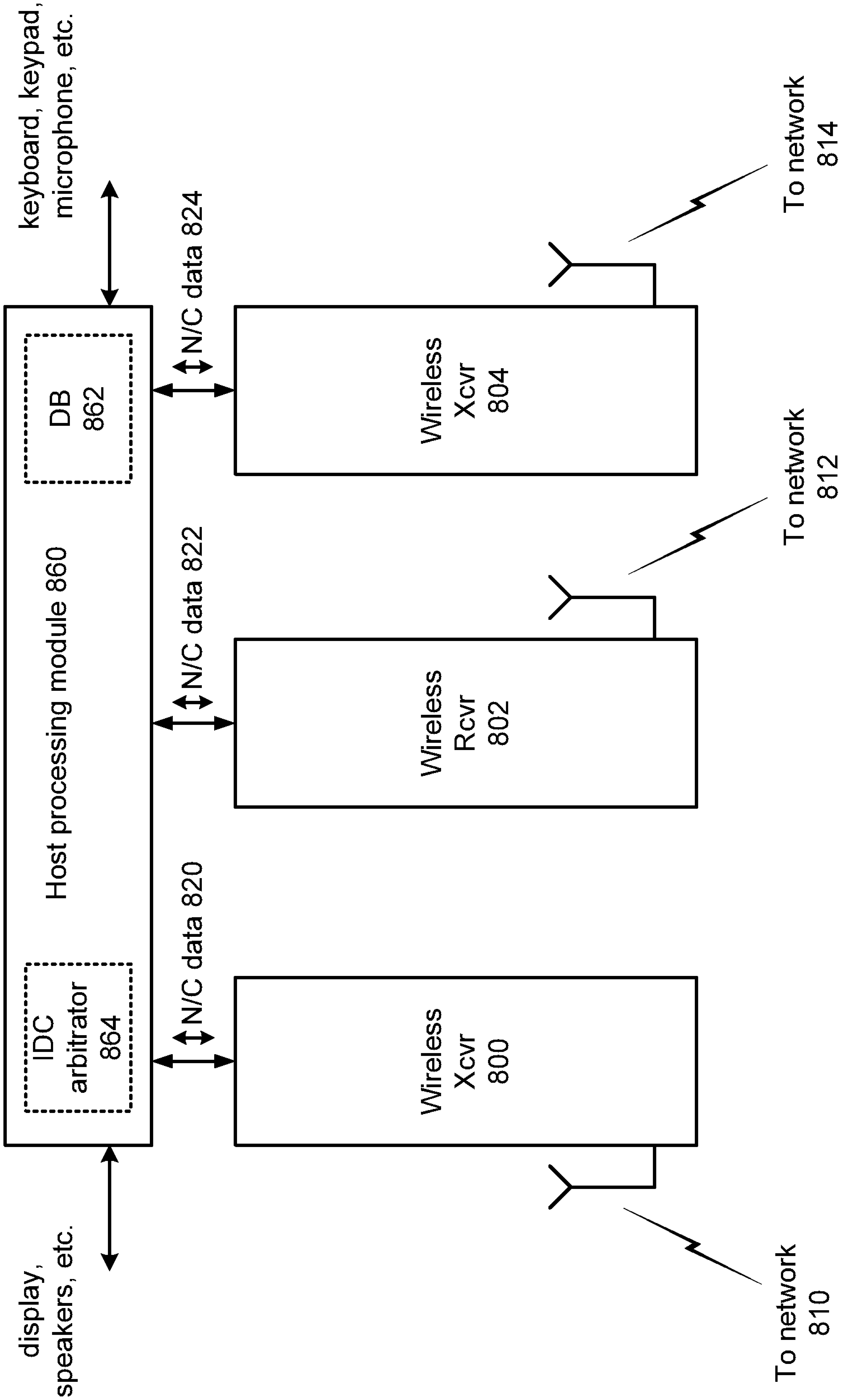

keyboard, keypad, microphone, etc.
display, speakers, etc.
Host processing module 860
DB 862
IDC arbitrator 864
N/C data 824
N/C data 822
N/C data 820
Wireless Xcvr 804
Wireless Rcvr 802
Wireless Xcvr 800
To network 814
To network 812
To network 810

FIG. 8

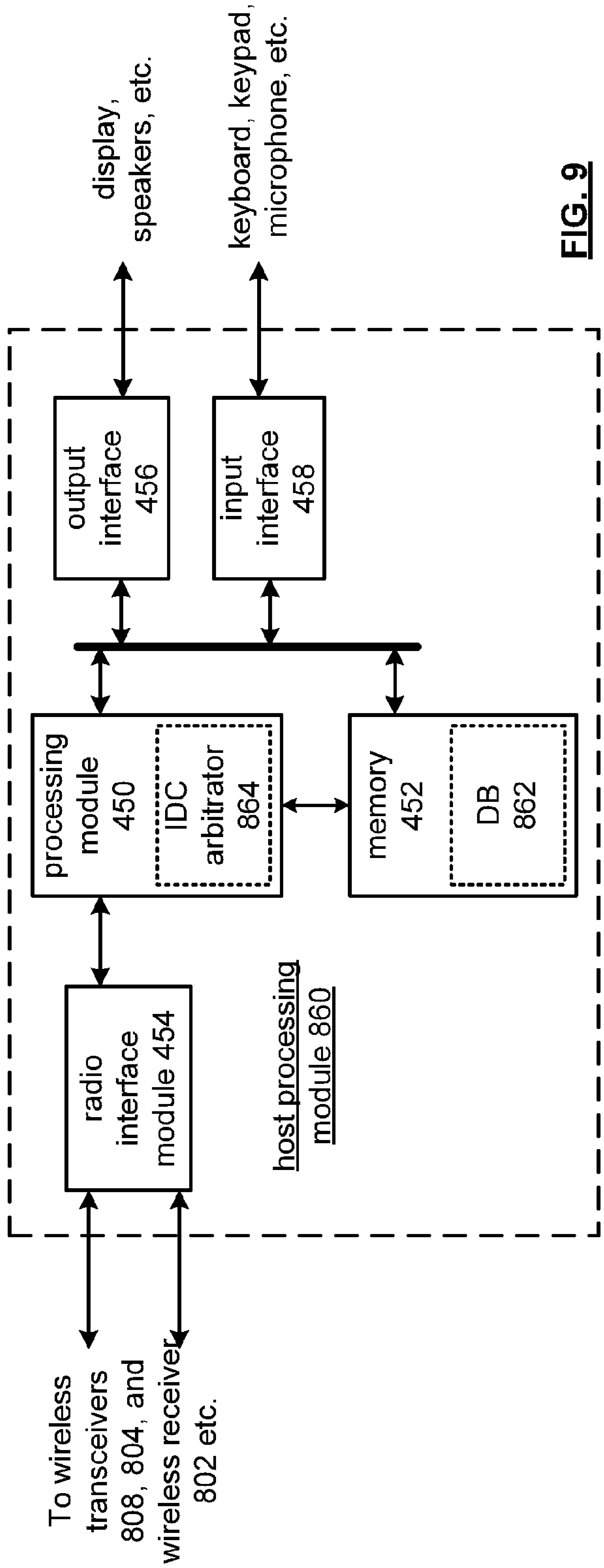

display, speakers, etc.
keyboard, keypad, microphone, etc.
output interface 456
input interface 458
processing module 450
IDC arbitrator 864
memory 452
DB 862
radio interface module 454
host processing module 860
To wireless transceivers 808, 804, and wireless receiver 802 etc.

FIG. 9

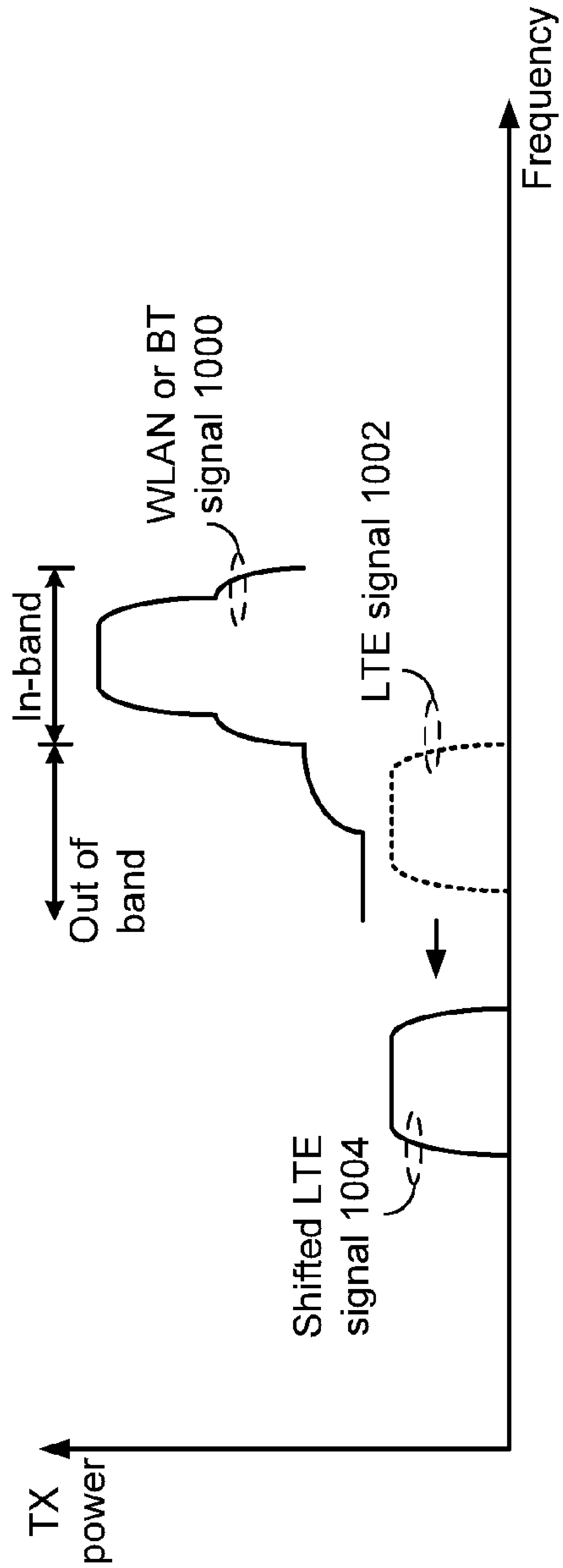

TX power
Frequency
In-band
Out of band
WLAN or BT signal 1000
LTE signal 1002
Shifted LTE signal 1004

FIG.10

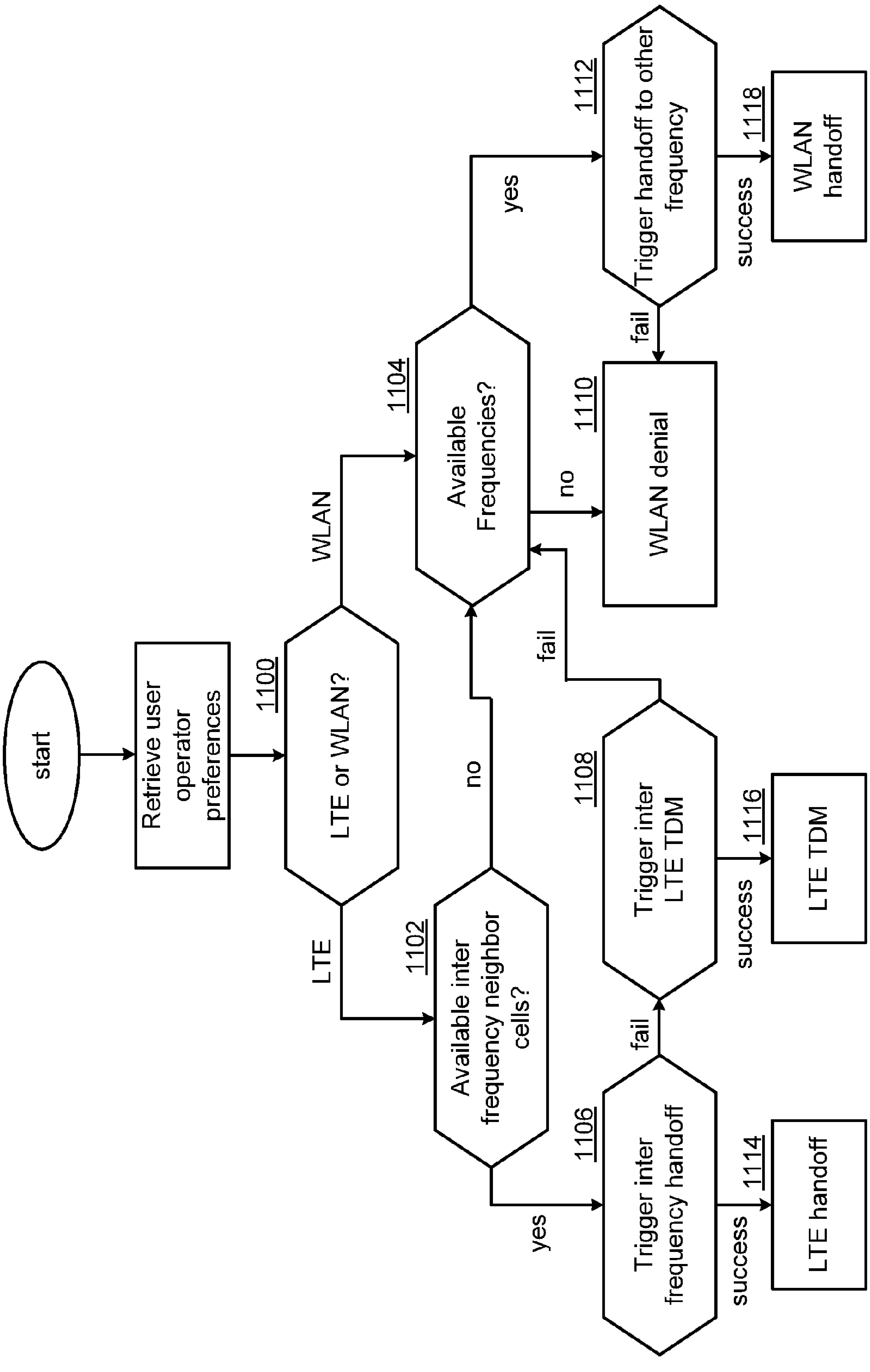

start
Retrieve user operator preferences
1100
LTE or WLAN?
LTE
WLAN
1102
Available inter frequency neighbor cells?
yes
no
1104
Available Frequencies?
yes
no
1106
Trigger inter frequency handoff
success
fail
1114
LTE handoff
1108
Trigger inter LTE TDM
success
fail
1116
LTE TDM
1110
WLAN denial
1112
Trigger handoff to other frequency
success
fail
1118
WLAN handoff

FIG. 11

MOBILE COMMUNICATION DEVICE WITH MULTIPLE WIRELESS TRANSCEIVERS AND METHODS FOR USE THEREWITH

CROSS REFERENCE TO RELATED PATENTS/PATENT APPLICATIONS

The present application claim priority under 35 USC 119 (e) to the following:

U.S. Provisional Patent Application Ser. No. 61/831,985 entitled "A MOBILE COMMUNICATION DEVICE WITH MULTIPLE WIRELESS TRANSCEIVERS AND METHODS FOR USE THEREWITH," filed Jun. 6, 2013;

the contents of which are hereby incorporated herein by reference in their entirety and made part of the present U.S. Provisional Patent Application for all purposes.

BACKGROUND

1. Technical Field

The various embodiments generally relate to communication systems; and, more particularly, relate to wireless communications via devices capable of communicating with two or more networks via differing protocols.

2. Description of Related Art

Depending on the type of wireless communication system, a wireless communication device, such as a cellular telephone, two-way radio, personal digital assistant (PDA), personal computer (PC), laptop computer, home entertainment equipment, etc., communicates directly or indirectly with other wireless communication devices. For direct communications (also known as point-to-point communications), the participating wireless communication devices tune their receivers and transmitters to the same channel or channels (e.g., one of the plurality of radio frequency (RF) carriers of the wireless communication system) and communicate over that channel or channels. For indirect wireless communications, each wireless communication device communicates directly with an associated base station (e.g., for cellular services) and/or an associated access point (e.g., for an in-home or in-building wireless network) via an assigned channel. To complete a communication connection between the wireless communication devices, the associated base stations and/or associated access points communicate with each other directly, via a system controller, via the public switch telephone network, via the Internet, and/or via some other wide area network.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

FIG. **1** is a diagram illustrating an embodiment of a wireless communication system.

FIG. **2** is a further diagram illustrating an embodiment of a wireless communication system.

FIG. **3** is a diagram illustrating an embodiment of components of a wireless communication device.

FIG. **4** is a diagram illustrating an embodiment of a host processing module **360**.

FIG. **5** is a diagram illustrating an embodiment of a radio **560**.

FIG. **6** is a flow diagram illustrating an embodiment of method.

FIG. **7** is a diagram illustrating an embodiment of components of a wireless communication device.

FIG. **8** is a diagram illustrating an embodiment of components of a wireless communication device.

FIG. **9** is a diagram illustrating an embodiment of a host processing module **360**.

FIG. **10** is a diagram illustrating an embodiment of a frequency spectrum.

FIG. **11** is a flow diagram illustrating an embodiment of method.

DETAILED DESCRIPTION

FIG. **1** is a diagram illustrating an embodiment of a wireless communication system. In particular, such a wireless communication system includes a plurality of base stations and/or access points **12**-**16**, a plurality of wireless communication devices **18**-**32** and a network hardware component **34**. The wireless communication devices **18**-**32** may be laptop host computers **18** and **26**, personal digital assistant hosts **20** and **30**, personal computer hosts **24** and **32** and/or cellular telephone hosts **22** and **28**. The details of embodiments of such wireless communication devices, including several optional functions and features are described in greater detail with reference to FIGS. **2** and **3**.

The base stations (BSs) or access points (APs) **12**-**16** are operably coupled to the network hardware **34** via local area network connections **36**, **38** and **40**. The network hardware **34**, which may be a router, switch, bridge, modem, system controller, etc., provides a wide area network connection **42** for the communication system **10**. Each of the base stations or access points **12**-**16** has an associated antenna or antenna array to communicate with the wireless communication devices in its area. Typically, the wireless communication devices register with a particular base station or access point **12**-**14** to receive services from the communication system **10**. For direct connections (i.e., point-to-point communications), wireless communication devices communicate directly via an allocated channel.

Typically, base stations are used for cellular telephone systems (e.g., advanced mobile phone services (AMPS), digital AMPS, global system for mobile communications (GSM), code division multiple access (CDMA), local multi-point distribution systems (LMDS), multi-channel-multi-point distribution systems (MMDS), Enhanced Data rates for GSM Evolution (EDGE), General Packet Radio Service (GPRS), high-speed downlink packet access (HSDPA), high-speed uplink packet access (HSUPA and/or variations thereof) 3GPP (third generation partnership project), LTE (long term evolution), UMTS (Universal Mobile Telecommunications System) and like-type systems, while access points are used for in-home or in-building wireless networks (e.g., IEEE 802.11, Bluetooth, ZigBee, any other type of radio frequency based network protocol and/or variations thereof). Regardless of the particular type of communication system, each wireless communication device includes a built-in radio and/or is coupled to a radio. Such wireless communication devices may operate in accordance with the various embodiments as presented herein to enhance performance, reduce costs, reduce size, and/or enhance broadband applications.

In various embodiments, the wireless communication devices **18**-**32** include a plurality of wireless transceivers for communication with at least two different wireless networks operating in accordance with at least different wireless communication protocols. Pre-association data received via one of the wireless transceiver from one of the wireless networks is shared with a second one of the wireless transceivers. The pre-association data is processed via the second wireless transceiver to support an association by a second wireless transceiver with a second one of the wireless networks.

Further details including several optional functions and features spanning multiple embodiments are presented in conjunction with FIGS. **2-6** that follow.

FIG. **2** is a further diagram illustrating an embodiment of a wireless communication system. As presented, pre-association data **204** is shared between a wireless network **200** and a wireless network **202**. The wireless communication device **22** includes a plurality of wireless transceivers for communication with the wireless networks **200** and **202** via BS or AP (**14** and **16**) in accordance with at least two different wireless communication protocols. Pre-association data **204** received via one of the wireless transceivers from wireless network **202** is shared with a second one of the wireless transceivers. The pre-association data **204** is processed via a second wireless transceiver to support an association by the second wireless transceiver with the wireless network **200**.

The operation of the wireless communication device **22** in conjunction with the wireless networks **200** and **202** is presented in conjunction with the examples that follow. In particular, consider the case where the wireless communication device is capable of communicating with both a wireless network **200** that is a local area network such as a 802.11u or 802.11uc compliant network or other network and a wireless network **202** that is a voice and data network, such as a 3GPP compliant network or other cellular or voice and data network.

WLAN/3GPP Radio interworking and integration is currently supported by 3GPP specifications at the core network level, including both seamless and non-seamless mobility to WLAN. For the Release 12, 3GPP is performing the standardization of LTE/UMTS RAN (radio access network) level enhancements for WLAN/3GPP Interworking via SID (study in detail) RP-122038. This targets the interworking between operators of a 3GPP core network and operators of WLAN access networks and hotspots. This interworking attempts to address the following issues:

1. Operator deployed WLAN networks are often under-utilized
2. User experience is suboptimal when UE connects to an overloaded WLAN network
3. Unnecessary WLAN scanning may drain UE battery resources
4. Allow operators to offload partially or completely LTE/UMTS traffic to their WLAN access points.

These solutions attempt to enhance operator control for WLAN interworking, and enable WLAN to be included in the operator's cellular Radio Resource Management, and allow operators to have a better handling of WLAN interface through a 3GPP LTE/UMTS modem. These solutions also attempt to provide enhancements to access network mobility and selection which take into account information such as radio link quality per UE (user equipment), backhaul quality, load, etc. for both cellular and WLAN access.

In accordance with these examples, IEEE 802.11u GAS (Generic Advertisement Service) is a Layer 2 transport mechanism which allows advertisements between a mobile device and a server in the network prior to authentication. The access point is responsible for relaying mobile device's queries to a server in the carrier's network and for delivering the server's response back to the device. This protocol uses GAS as a transport to discover a range of metadata from the access point. A traditional IEEE 802.11u device executes the following steps in establishing connectivity:

1. The device scans for hotspots available.
2. The device and the network GAS provide for Layer 2 transport of advertisement frames between the device and a server in the network prior to the authentication phase.
3. ANQP is used to discover different features and available services of the network.
4. The device proceeds to the authentication process.

In an embodiment, the pre-association data **204** can be formatted in accordance with a query and response protocol, such as the IEEE 802.11u ANQP (Access Network Query Protocol) discussed above. In operation, the mobile device **22**, unlike traditional systems, exchanges ANQP data via the 3GPP network and shares this ANQP data between 802.11x and 3GPP transceivers in order to facilitate the association of the 802.11x transceiver with the 802.11u or 802.11uc network.

FIG. **3** is a diagram illustrating an embodiment of components of a wireless communication device. A mobile communication device, such as devices **18-32**, includes a plurality of wireless transceivers **300** and **304** that operate in conjunction with a host processing module **360**. The wireless transceiver **300** communicates with a wireless network **200** and the wireless transceiver **304** communicates with a wireless network **202**. The wireless network **200** supports communication via a first wireless protocol and the wireless network **202** supports communication via a second wireless protocol that is different from the first wireless protocol.

The wireless transceiver **304** communicates pre-association data **204** via the wireless network **202**. The pre-association data **204** relates to the wireless network **200**. The wireless transceiver **300** communicates the pre-association data with the wireless transceiver **304** via a transceiver interface **302**. This communication can include both queries and responses by either the wireless transceiver **300** or the wireless network **200** that are carried via the wireless transceiver **304** and the wireless network **202**. The wireless transceiver **300** processes the pre-association data received from the network **200** in this fashion to support an association by the wireless transceiver **300** with the wireless network **200**.

In one example of operation, the two wireless transceivers support communication via a plurality of protocols. For example, wireless transceiver **300** or **304** may be compatible with IEEE 802.11(a), IEEE 802.11(b), IEEE 802.11(g), IEEE 802.11(n), 802.11u or 802.11uc as well as in accordance with various embodiments. Further, while a single antenna is shown schematically, the wireless transceivers **300** and/or **304** may each include multiple antennas and may support MIMO (multi-input multi-output) dimensions to 4×4 and greater. In addition or in the alternative, wireless transceiver **300** or **304** may be compatible with advanced mobile phone services (AMPS), digital AMPS, global system for mobile communications (GSM), code division multiple access (CDMA), local multi-point distribution systems (LMDS), multi-channel-multi-point distribution systems (MMDS), Enhanced Data rates for GSM Evolution (EDGE), General Packet Radio Service (GPRS), high-speed downlink packet access (HSDPA), high-speed uplink packet access (HSUPA and/or variations thereof) LTE, UMTS and like-type systems, Bluetooth, ZigBee, and NFC (near field communications) and/or any other type of radio frequency based network protocol and/or variations thereof.

In addition to supporting the transfer of pre-association data **204**, the transceiver interface **302** can be implemented via a general coexistence interface that is configured in different modes to support the transfer of different combinations of co-existence data **306** to avoid interference between the wireless transceivers **300** and **304** and their respective communications with wireless networks **200** and **202**. In this fashion, GSM, LTE, 802.11x, and Bluetooth transceivers and/or a GPS (global positioning system) receiver that may utilize a common frequency spectrum can share coexistence data to reduce or avoid interference. In addition or in the alternative, the transceiver interface can include a bus structure, serial interface, parallel interface or other data interface.

Various embodiments apply to wireless radiotelephony equipment with multiple co-located radio modules ranging from LTE, WLAN, and Bluetooth to GPS. Consider an example where wireless transceiver **300** and wireless network **200** operate in accordance with 802.11u or 802.11uc and wireless transceiver **304** and wireless network **202** operate in accordance with 3GPP via UMTS or LTE modem.

As discussed in conjunction with FIG. **2**, LTE and UMTS Release 12 support 3GPP/WLAN interworking via dedicated RAN mechanisms. Wireless networks **200** and **202** share pre-association data **204** via such interworking. In one example, interworking between WLAN APs in network **200** and eNode Bs in wireless network **202** allow the acquisition of information by the eNode Bs about the APs in their vicinity. This also includes the information provided through interaction of wireless network **202** with wireless network **200** via a WLAN ANQP Server or other network component.

In this configuration, the wireless transceiver **304** receives and optionally transmits 802.11u or 802.11uc pre-association data **204** over LTE or UMTS dedicated signaling on behalf of the wireless transceiver **300**. In particular, the wireless transceiver **304** can provide this functionality via a query/response 3GPP RAN mechanism. The pre-association data **204** shared in this fashion is communicated internally to the wireless transceiver **300** via the transceiver interface **302**. This provides the following advantages:

1. Allows the 802.11u or 802.11uc transceiver to use the 3GPP modem to retrieve ANQP information without scanning and connecting to any access points—even without powering on the radio portion of the transceiver.
2. Allows an 802.11x transceiver (WLAN pre 802.11u or other 802.11x) to use ANQP information even not supported natively or not supporting 802.11u or 802.11uc.
3. Reduces the overall latency of the connection process to wireless network **200**.
4. Reduces the power consumption by simplifying the connection to the wireless network **200**, and making the AP selection with the radio of wireless transceiver **300** offline.
5. Avoids use of the host processing module to exchange the ANQP information between the wireless transceiver **300** and wireless transceiver **304**.

Examples of pre-association data **204** in various ANQP embodiments are presented in the table below.

Information	source	Length (bytes)	Destination	Description
Venue Name	LTE/ UMTS modem	6-65540	WLAN xcvr	Zero or more venue names associated with the BSS
Emergency Call Number	LTE/ UMTS modem	4-65540	WLAN xcvr	List of emergency phone numbers
Network Authentication Type	LTE/ UMTS modem	4-65540	WLAN xcvr	List of network authentication types
Roaming Consortium List	LTE/ UMTS modem	4-65540	WLAN xcvr	Consortium and/or SSPs networks accessible via AP
IP Address Type	LTE/ UMTS modem	5	WLAN xcvr	IP address version and type to be allocated to the UE
NAI Realm List	LTE/ UMTS modem	6-65540	WLAN xcvr	NAI realms corresponding to SSPs or other entities whose networks or services are accessible via this AP
3GPP Cellular Network	LTE/ UMTS modem	4-65540	WLAN xcvr	PLMN list of 3GPP networks accessible through AP
AP geospatial location	LTE/ UMTS modem	22	WLAN xcvr	Location coordinates and resolution (latitude/longitude/altitude) of AP
AP Civic Location	LTE/ UMTS modem	4-65540	WLAN xcvr	Postal address of AP
AP Location Public Id. URI	LTE/ UMTS modem	4-65540	WLAN xcvr	URI reference to where location information for the AP
Domain Name List	LTE/ UMTS modem	4-65540	WLAN xcvr	Domain name(s) of the entity operating the network
Emergency Alert Id. URI	LTE/ UMTS modem	4-65540	WLAN xcvr	URI for EAS message retrieval
Emergency NAI	LTE/ UMTS modem	4-65540	WLAN xcvr	Identity string used for emergency access requests
ANQP Vendor-Specific list	LTE/ UMTS modem	4-65540	WLAN xcvr	Vendor-Specific information not defined in standard
Venue info	LTE/ UMTS modem	2	WLAN xcvr	Group and Type of venue where the AP is located
Extended Capabilities info.	LTE/ UMTS modem	variable	WLAN xcvr	Bitmap identifying features supported by AP

The interoperability between the mobile communication device (UE) and wireless networks **200** and **202** can be described in conjunction with the following further example. Consider again the case where wireless transceiver **300** and wireless network **200** operate in accordance with 802.11u or 802.11uc and wireless transceiver **304** and wireless network **202** operate in accordance with 3GPP via UMTS/LTE. In this particular case, a 3GPP call is offloaded onto a WLAN operated by the operator of the 3GPP network.

The UE is connected to network **202** via UMTS/LTE. The wireless network **202** and the wireless transceiver **304** (LTE/UMTS modem) support Release 12 RRC signaling or SIB broadcast for WLAN interworking. The wireless network **202** prepares WLAN offloading. In particular, the wireless network **202** knows the location of the UE (Cell ID) and the location of its own APs. The wireless network **202** sends ANQP information to the UE through LTE or UMTS modem. The LTE/UMTS modem initiates contact with the wireless transceiver **300** via the transceiver interface **302**. The LTE/UMTS modem uses the transceiver interface **302** to send all received ANQP information to the wireless transceiver **300** (WLAN transceiver). The LTE/UMTS modem need not use the host processing module **360** of the phone for this exchange—which can reduce power consumption. Each time the LTE/UMTS modem receives updated ANQP information from the 3GPP network (wireless network **202**), it sends this information to the WLAN transceiver. If the WLAN transceiver requires any ANQP information, it will use the transceiver interface **302** to require LTE/UMTS modem to assist him and query the wireless network **202** for the ANQP information. When the LTE/UMTS modem receives the ANQP information and the AP information, it can directly connect to the AP, as selected by the wireless transceiver **300** or required by the operator of wireless network **200** and **202**.

FIG. **4** is a diagram illustrating an embodiment of a host processing module **360**. As illustrated, the host processing device **360** includes a processing module **450**, memory **452**, radio interface **454**, input interface **458** and output interface **456**. The processing module **450** and memory **452** execute the corresponding instructions that are typically done by the host device. For example, for a cellular telephone host device, the processing module **450** performs the corresponding communication functions corresponding to the wireless transceivers **300** and **304** as well as other functions of the devices.

The radio interface module **454** allows data to be received from and sent to two or more wireless transceivers **300**, **304**, etc. For inbound data, the radio interface module **454** provides the data to the processing module **450** for further processing and/or routing to the output interface **456**. The output interface **456** provides connectivity to an output display device such as a display, monitor, speakers, etc. such that the received data may be displayed. The radio interface **454** also provides data from the processing module **450** to the wireless transceivers **300**, **304**, etc. The processing module **450** may receive the outbound data from an input device such as a keyboard, keypad, microphone, etc. via the input interface **458** or generate the data itself. For data received via the input interface **458**, the processing module **450** may perform a corresponding host function on the data and/or route it to one of the wireless transceivers **300**, **304** via the radio interface module **454**.

FIG. **5** is a diagram illustrating an embodiment of a radio **560**. In particular, radio **560** presents an example of wireless transceiver **300** and/or **304** that includes multiple antennas for optional MIMO operation. Radio **560** includes an interface **562**, a baseband processing module **564**, memory **566**, a plurality of radio frequency (RF) transmitters **568-572**, a transmit/receive (T/R) module **574**, a plurality of antennas **582-586**, a plurality of RF receivers **576-580**, and a local oscillation module **510**. The baseband processing module **564**, in combination with operational instructions stored in memory **566**, execute digital receiver functions and digital transmitter functions, respectively. In operation, the radio **560** receives outbound data **588** and control information from either the host device or transceiver interface **302** via the interface **562**. The baseband processing module **564** receives the outbound data **588** and, based on a mode selection signal **502**, produces one or more outbound symbol streams **590**.

The baseband processing module **564**, based on the mode selection signal **502** produces the one or more outbound symbol streams **590** from the output data **588**. For example, if the mode selection signal **502** indicates that a single transmit antenna is being utilized for the particular mode that has been selected, the baseband processing module **564** will produce a single outbound symbol stream **590**. Alternatively, if the mode select signal indicates 2, 3 or 4 antennas, the baseband processing module **564** will produce 2, 3 or 4 outbound symbol streams **590** corresponding to the number of antennas from the output data **588**.

Depending on the number of outbound streams **590** produced by the baseband module **564**, a corresponding number of the RF transmitters **568-572** will be enabled to convert the outbound symbol streams **590** into outbound RF signals **592**. The transmit/receive module **574** receives the outbound RF signals **592** and provides each outbound RF signal to a corresponding antenna **582-586**.

When the radio **560** is in the receive mode, the transmit/receive module **574** receives one or more inbound RF signals via the antennas **582-586**. The T/R module **574** provides the inbound RF signals **594** to one or more RF receivers **576-580**. The RF receiver **576-580** converts the inbound RF signals **594** into a corresponding number of inbound symbol streams **596**. The number of inbound symbol streams **596** will correspond to the particular mode in which the data was received. The baseband processing module **564** receives the inbound symbol streams **590** and converts them into inbound data **598**, which is provided to the host device via the host interface **562** of the a companion transceiver via transceiver interface **302**.

FIG. **6** is a flow diagram illustrating an embodiment of method. In particular, a method is presented for use in conjunction with one or more functions and features described in conjunction with FIGS. **1-5**. Step **600** includes communicating pre-association data with a first wireless network via a first wireless transceiver of a mobile communication device, the pre-association data relating to a second wireless network, wherein the first wireless network supports communication via a first wireless protocol and wherein the second wireless network supports communication via a second wireless protocol that is different from the first wireless protocol. Step **602** includes communicating the pre-association data between the first wireless transceiver and a second wireless transceiver of the mobile communication device via a transceiver interface, wherein the pre-association data includes query and response protocol data. Step **604** includes processing the pre-association data to support an association by the second wireless transceiver with the second wireless network.

In an embodiment, the first wireless network supports voice and data communications and the second wireless network is a local area network. The pre-association data includes metadata associated with the second wireless network, features associated with the second wireless network, and/or services available via the second wireless network.

The pre-association data can be processed to support an association by the second wireless transceiver with the second wireless network, prior to the second wireless transceiver communicating with the second wireless network. The second wireless network can communicate the pre-association data via the first wireless network. The transceiver interface can further communicate co-existence data between the first wireless transceiver and the second wireless transceiver to control interference between the first wireless transceiver and the second wireless transceiver.

FIG. **7** is a diagram illustrating an embodiment of components of a wireless communication device. In particular, a wireless communication device is presented that includes many similar elements described in conjunction with FIG. **3** that are referred to by common reference numerals. In this embodiment, however, the transceiver interface **302** is optionally included to share co-existence data **306** between the wireless transceivers **300** and **304**. The pre-association data **204** is shared between wireless transceivers **300** and **304** via the host processing module **360**. In particular, the radio interface module **454** and/or processing module **450** provide a bridge between the wireless transceiver **300** and wireless transceiver **304** to provide interworking or otherwise share pre-association data **204** between wireless transceivers **300** and **304**.

In an embodiment, the wireless transceiver **300** includes a Bluetooth/WLAN combined transceiver and wireless transceiver **304** includes an MWS (mobile wireless standard) device or other 3GPP device such as a (LTE/UMTS modem). The host processing module **360** provides a HCI (host controller interface) compliant with the BT-SIG standard that allows the LTE/UMTS modem and BT/WLAN transceiver to exchange information including pre-association data **204** and optionally coexistence data **306** to support cooperative coexistence. In particular, MWS Coexistence logical signaling defines a set of signals between the collocated BT/WLAN transceiver (operating as a Bluetooth Controller) and the MWS device. Those signals carry time critical information such as the start point of an MWS frame. The coexistence logical signaling architecture also includes a transparent data messaging mechanism to enable passing of information between the MWS device and Bluetooth Controller when such information cannot tolerate the long latency (tens of milliseconds). In-device coexistence signaling can be provided through a BT-SIG WCI-2 standardized interface that supports coexistence between LTE/UMTS and BT/WLAN transceivers.

In addition to providing co-existence support, the HCI BT-SIG WCI-2 interface bridging provided by the host processing module **360** can be extended to support 3GPP-WLAN RAN interworking and especially to provide WLAN ANQP information from the LTE/UMTS modem of wireless transceiver **304** to the BT/WLAN portion of wireless transceiver **300**. This information can be received through RRC (radio resource control) layer of the LTE/UMTS modem. In particular, this extend BT-SIG WCI-2 interface provided by host processing module **360** allows the wireless transceiver **300** to query ANQP parameters via the wireless transceiver **304**.

FIG. **8** is a diagram illustrating an embodiment of components of a wireless communication device. In particular, a wireless communication device is presented that includes many similar elements described in conjunction with FIG. **3** that are referred to by common reference numerals. In this embodiment however, a host processing module **860** operates in a similar fashion to host processing module **360**, however, it shares network and control (N/C) data **820**, **822** and **824** with wireless transceivers **800** and **804** and wireless receiver **802** and/or other collocated receivers, transmitters and transceivers. The wireless transceivers **800** and **804** and wireless receiver **802** can include a BT/WLAN transceiver, 3GPP transceiver such as an LTE/UMTS modem or other 3GPP transceiver, a GPS receiver and/or other wireless transceiver or receiver. Similarly, the networks **810**, **812** and **814** can include a Bluetooth, network, WLAN network, 3GPP network, and/or other wireless networks. Further examples include transceivers and corresponding networks that operate in accordance with advanced mobile phone services (AMPS), digital AMPS, global system for mobile communications (GSM), code division multiple access (CDMA), local multipoint distribution systems (LMDS), multi-channel-multipoint distribution systems (MMDS), Enhanced Data rates for GSM Evolution (EDGE), General Packet Radio Service (GPRS), high-speed downlink packet access (HSDPA), high-speed uplink packet access (HSUPA and/or variations thereof), ZigBee, and NFC (near field communications).

In operation, the host processing module **860** gathers network data from the wireless transceivers **800** and **804** and/or wireless receiver **802** and creates a database of channel information relating to channels, frequencies, frequency bands and other spectral information. For example, the network information can include information on noise and interference, channel usage by the collocated transceivers and receivers, user preferences, operator preferences along with timing and/or other spectral information generated in the form of reports that are generated by the wireless transceivers **800** and **804** and wireless receiver **802** and/or other collocated receivers, transmitters and transceivers and shared with the host processing module **860** via network control data **820**, **822**, **824**, ... This network and control data **820**, **822**, **824** can be stored in a database **862**.

The host processing module **860** further includes an IDC (intra-device coexistence) arbitrator **864** that determines an IDC methodology and controls coexistence via commands sent to the wireless transceivers **800** and **804** and/or wireless receiver **802** via the network and control data **820**, **822** and **824**. The IDC arbitrator **864** retrieved network and control data **820**, **822** and/or **824** from the database **862** and analyzes this data to rank different possible IDC schemes in a rank ordering—in order or preference or likelihood of success, etc.

An embodiment of the operation of the IDC arbitrator **864** can be described in conjunction with the example that follows. Consider the case where the wireless transceiver **800** is a BT/WLAN transceiver, wireless receiver **802** is a GPS receiver and wireless transceiver **804** is a LTE/UMTS modem. These collocated RF technologies suffer from interference to each other, causing service interrupt or degraded link or packet-level performance due to physical proximity, spectral closeness, imperfection of RF filtering that drifts with temperature, and RF harmonics or intermediate modulations. Even the simultaneous transmission and reception by the same RF technology over same or different carriers, such as LTE Carrier Aggregation and LTE/3G data-plus-2G voice, may see similar problem. Further, WLAN, GPS and BT (ISM) can both operate at 2.4 GHz ISM band, which can't be resolved by purely RF-level filtering for a single-die WLAN-BT combo chip.

In accordance with this example, the IDC arbitrator **864** collects and stores information received from the wireless transceiver **800** and **804** and the wireless receiver **802** in the database **862**. This information can include network data regarding LTE serving cells and authorized neighbors cells, WLAN available frequencies and user/operators preferences such as LTE band, frequencies, RSSI (receive signal strength indication), RSRP (reference signal received power), RSRQ (reference signal received quality), user preferences, BT/WIFI frequencies, signal levels and GPS frequencies.

IDC Arbitrator **864** analyzes the information from the database **862** and optionally makes a decision to trigger a specific IDC procedure in one or more specific technology—and sends command data via network and control data **820**, **822** and/or **824** to control the appropriate changes in the wireless transceivers **800** and **804** and/or the wireless receiver **802**. These different schemes, for example, include but are not limited to:

Move the LTE signal away from the BT/WLAN frequencies by performing inter-frequency handover within E-UTRAN (LTE).

Have the UE request the network to perform time domain scheduling to reserve some time for BT/WLAN/GPS activities, critical or otherwise.

Have the UE to autonomously decide to use some times for BT/WLAN/GPS activities and deny any LTE activity during this time.

Change WLAN channels if channels are available.

Deny BT/WLAN transmissions during certain times.

Etc.

FIG. **9** is a diagram illustrating an embodiment of a host processing module **860**. In particular, a host processing module **860** is presented that includes many similar elements to the host processing module **360** that are referred to by common reference numerals. As shown, the IDC arbitrator is implemented via processing module **450** and the database **862** is implemented via memory **452**. It should be noted that, which shown as being incorporated in other elements, the IDC arbitrator **864** and database **862** can, in the alternative, be implemented via dedicated hardware such as a dedicated processing device and dedicated memory device.

As discussed in conjunction with FIG. **8**, the IDC arbitrator **864** collects and stores information received from the wireless transceiver **808** and **804** and the wireless receiver **802** in the database **862**. IDC Arbitrator **864** analyzes the information from the database **862** and optionally makes a decision to trigger a specific IDC procedure in one or more specific technology—and sends command data via network and control data **820**, **822** and/or **824** to control the appropriate changes in the wireless transceivers **800** and **804** and/or the wireless receiver **802**.

FIG. **10** is a diagram illustrating an embodiment of a frequency spectrum. The spectral diagram illustrates a diagram of frequency versus power for a wireless communication device, such as any of the wireless communication devices **18-32**. A particular portion of a frequency spectrum is illustrated to accentuate certain principles and is not drawn to scale. In particular, this diagram follows through with the example presented in conjunction with FIG. **8** where the wireless transceivers **800** and **804** include a BT/WLAN transceiver and 3GPP transceiver such as an LTE/UMTS modem.

In this example, a BT/WLAN signal **1000** includes both in-band and out of band signal components. In particular, out of band components, caused by, for example, bandpass filter roll-off or insufficient antenna isolation could potentially interference with the LTE signal **1002**. The IDC arbitrator detects this condition and locates the availability of neighboring LTE frequencies and controls the handoff as shown by shifted LTE signal **1004**.

FIG. **11** is a flow diagram illustrating an embodiment of method. In particular, a method is presented for use in conjunction with one or more functions and features described in conjunction with FIGS. **1-10**. In particular, this method follows through with the example presented in conjunction with FIG. **8** where the wireless transceivers **800** and **804** include a BT/WLAN transceiver and 3GPP transceiver such as an LTE/UMTS modem and further where a potential conflict is detected between the two modes of operation. The method is suitable for use by the IDC arbitrator **864** to determine how to select an IDC scheme such as either LTE handoff to a new frequency, LTE TDM, WLAN handoff to a new frequency or simple WLAN denial of service.

In step **1100**, the IDC arbitrator **864** retrieves user operator preferences and/or other network and control data **820** and **824** from the database **862**. The method determines whether LTE or WLAN IDC solutions should be selected, based on user preferences, operator preferences or other data as shown in step **1100**. When LTE is selected, the method proceeds to step **1102** where the IDC arbitrator **864** determines if there are available inter frequency neighbor cells. If not, the method proceeds to step **1104**. If so, the method proceeds to step **1106** where the IDC arbitrator **864** attempt to trigger an inter frequency handoff to the neighbor cell or cells. If this succeeds, the LTE handoff is used as shown in step **1114**. If the handoff fails, the method proceeds to step **1108** where the IDC arbitrator **864** triggers an LTE TDM (time division multiplexing). If this is successful, the LTE TDM is used as shown in step **1116**. If not, the method proceeds to step **1104**.

In step **1104**, the IDC arbitrator **864** focuses on WLAN IDC solutions and checks for available frequencies. If none are available, the method proceeds to step **1110**, where WLAN is denied. If frequencies are available the method proceeds to step **1112** where the IDC arbitrator **864** triggers handoff to other frequencies. If this fails, WLAN operation is denied as shown in step **1110**. If this handoff is successful, the method proceeds with the WLAN handoff as shown in step **1118**.

It should be noted that the example described above and other methodologies can be applied to additional IDC schemes, additional radio technologies and different decision criteria, in various other embodiments.

As may also be used herein, the term(s) "operably coupled to", "coupled to", and/or "coupling" includes direct coupling between items and/or indirect coupling between items via an intervening item (e.g., an item includes, but is not limited to, a component, an element, a circuit, and/or a module) where, for indirect coupling, the intervening item does not modify the information of a signal but may adjust its current level, voltage level, and/or power level. As may further be used herein, inferred coupling (i.e., where one element is coupled to another element by inference) includes direct and indirect coupling between two items in the same manner as "coupled to". As may even further be used herein, the term "operable to" or "operably coupled to" indicates that an item includes one or more of power connections, input(s), output(s), etc., to perform, when activated, one or more its corresponding functions and may further include inferred coupling to one or more other items. As may still further be used herein, the term "associated with", includes direct and/or indirect coupling of separate items and/or one item being embedded within another item.

As may also be used herein, the terms "processing module", "module", "processing circuit", and/or "processing unit" (e.g., including various modules and/or circuitries such as may be operative, implemented, and/or for encoding, for decoding, for baseband processing, etc.) may be a single processing device or a plurality of processing devices. Such a processing device may be a microprocessor, micro-controller, digital signal processor, microcomputer, central processing unit, field programmable gate array, programmable logic device, state machine, logic circuitry, analog circuitry, digital circuitry, and/or any device that manipulates signals (analog and/or digital) based on hard coding of the circuitry and/or operational instructions. The processing module, module, processing circuit, and/or processing unit may have an associated memory and/or an integrated memory element, which may be a single memory device, a plurality of memory devices, and/or embedded circuitry of the processing module, module, processing circuit, and/or processing unit. Such a memory device may be a read-only memory (ROM), random access memory (RAM), volatile memory, non-volatile memory, static memory, dynamic memory, flash memory, cache memory, and/or any device that stores digital information. Note that if the processing module, module, processing circuit, and/or processing unit includes more than one processing device, the processing devices may be centrally located (e.g., directly coupled together via a wired and/or wireless bus structure) or may be distributedly located (e.g., cloud computing via indirect coupling via a local area network and/or a wide area network). Further note that if the processing module, module, processing circuit, and/or processing unit implements one or more of its functions via a state machine, analog circuitry, digital circuitry, and/or logic circuitry, the memory and/or memory element storing the corresponding operational instructions may be embedded within, or external to, the circuitry comprising the state machine, analog circuitry, digital circuitry, and/or logic circuitry. Still further note that, the memory element may store, and the processing module, module, processing circuit, and/or processing unit executes, hard coded and/or operational instructions corresponding to at least some of the steps and/or functions illustrated in one or more of the Figures. Such a memory device or memory element can be included in an article of manufacture.

Various embodiments have been described above with the aid of method steps illustrating the performance of specified functions and relationships thereof. The boundaries and sequence of these functional building blocks and method steps have been arbitrarily defined herein for convenience of description. Alternate boundaries and sequences can be defined so long as the specified functions and relationships are appropriately performed. Any such alternate boundaries or sequences are thus within the scope and spirit of the claims. Further, the boundaries of these functional building blocks have been arbitrarily defined for convenience of description. Alternate boundaries could be defined as long as the certain significant functions are appropriately performed. Similarly, flow diagram blocks may also have been arbitrarily defined herein to illustrate certain significant functionality. To the extent used, the flow diagram block boundaries and sequence could have been defined otherwise and still perform the certain significant functionality. Such alternate definitions of both functional building blocks and flow diagram blocks and sequences are thus within the scope and spirit of the claims. One of average skill in the art will also recognize that the functional building blocks, and other illustrative blocks, modules and components herein, can be implemented as illustrated or by discrete components, application specific integrated circuits, processors executing appropriate software and the like or any combination thereof.

A physical embodiment of an apparatus, an article of manufacture, a machine, and/or of a process that includes one or more embodiments may include one or more of the aspects, features, concepts, examples, etc. described with herein. Further, from figure to figure, the embodiments may incorporate the same or similarly named functions, steps, modules, etc. that may use the same or different reference numbers and, as such, the functions, steps, modules, etc. may be the same or similar functions, steps, modules, etc. or different ones.

The term "module" is used in the description of the various. A module includes a functional block that is implemented via hardware to perform one or module functions such as the processing of one or more input signals to produce one or more output signals. The hardware that implements the module may itself operate in conjunction software, and/or firmware. As used herein, a module may contain one or more sub-modules that themselves are modules.

While particular combinations of various options, methods, functions and features have been expressly described herein, other combinations of these options, methods, functions and features are likewise possible. The various embodiments are not limited by the particular examples disclosed herein and expressly incorporates these other combinations.

What is claimed is:

1. A mobile communication device, comprising:

a first wireless transceiver that communicates pre-association data via a first wireless network, the pre-association data relating to a second wireless network, wherein the first wireless network supports communication via a first wireless protocol and wherein the second wireless network supports communication via a second wireless protocol that is different from the first wireless protocol;

a transceiver interface coupled to the first wireless transceiver; and

a second wireless transceiver, coupled to the first wireless transceiver, that communicates the pre-association data with the first wireless transceiver via the transceiver interface and processes the pre-association data to support an association by the second wireless transceiver with the second wireless network;

wherein the pre-association data includes services available via the second wireless network; and

wherein the transceiver interface further communicates co-existence data between the first wireless transceiver and the second wireless transceiver to control interference between the first wireless transceiver and the second wireless transceiver.

2. The mobile communication device of claim **1**, wherein the second wireless network is a local area network.

3. The mobile communication device of claim **2**, wherein the pre-association data includes query and response protocol data.

4. The mobile communication device of claim **2**, wherein the pre-association data includes metadata associated with the second wireless network.

5. The mobile communication device of claim **2**, wherein the pre-association data includes features associated with the second wireless network.

6. The mobile communication device of claim **1**, wherein the second wireless transceiver processes the pre-association data to support the association by the second wireless transceiver with the second wireless network, prior to the second wireless transceiver communicating with the second wireless network.

7. The mobile communication device of claim **1**, wherein the second wireless network communicates the pre-association data via the first wireless network.

8. The mobile communication device of claim **1**, wherein the first wireless network supports voice and data communications.

9. A method comprising:

communicating pre-association data with a first wireless network via a first wireless transceiver of a mobile communication device, the pre-association data relating to a second wireless network, wherein the first wireless network supports communication via a first wireless protocol and wherein the second wireless network supports communication via a second wireless protocol that is different from the first wireless protocol;

communicating the pre-association data between the first wireless transceiver and a second wireless transceiver of the mobile communication device via a transceiver interface, wherein the pre-association data includes query and response protocol data; and

processing the pre-association data to support an association by the second wireless transceiver with the second wireless network; and

communicating co-existence data between the first wireless transceiver and the second wireless transceiver via the transceiver interface to control interference between the first wireless transceiver and the second wireless transceiver.

10. The method of claim **9**, wherein the second wireless network is a local area network.

11. The method of claim **9**, wherein the pre-association data includes metadata associated with the second wireless network.

12. The method of claim **9**, wherein the pre-association data includes at least one of: features associated with the second wireless network, and services available via the second wireless network.

13. The method of claim **9**, wherein the pre-association data is processed to support an association by the second wireless transceiver with the second wireless network, prior to the second wireless transceiver communicating with the second wireless network.

14. The method of claim **9**, wherein the second wireless network communicates the pre-association data via the first wireless network.

15. The method of claim **9**, wherein the first wireless network supports voice and data communications.

16. A mobile communication device, comprising:

a first wireless transceiver that communicates pre-association data via a first wireless network, the pre-association data relating to a second wireless network, wherein the first wireless network supports communication via a first wireless protocol, wherein the second wireless network supports communication via a second wireless protocol that is different from the first wireless protocol, wherein the second wireless network is a local area network and wherein the pre-association data includes query and response protocol data regarding features and services available via the second wireless network;

a transceiver interface coupled to the first wireless transceiver; and

a second wireless transceiver, coupled to the first wireless transceiver, that communicates the pre-association data with the first wireless transceiver via the transceiver interface and processes the pre-association data to support an association by the second wireless transceiver with the second wireless network, prior to the second wireless transceiver communicating with the second wireless network; and

wherein the transceiver interface further communicates co-existence data between the first wireless transceiver and the second wireless transceiver to control interference between the first wireless transceiver and the second wireless transceiver.

17. The mobile communication device of claim **16**, wherein the second wireless network communicates the pre-association data via the first wireless network.

18. The mobile communication device of claim **16**, wherein the first wireless network supports voice and data communications.

19. The mobile communication device of claim **16**, wherein the first wireless transceiver supports multi-input, multi-output (MIMO) communications via a plurality of antennas.

20. The mobile communication device of claim **19**, wherein the second wireless transceiver supports multi-input, multi-output (MIMO) communications via the plurality of antennas.

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